

Appl. No. : 09/945,065  
Filed : August 30, 2001

### REMARKS

With this amendment, Claims 1-4 and 6-20 are pending in the present application. Claim 1 and 14 have been amended and Claim 5 has been canceled. The specific amendments made to the claims are shown in the "Version With Markings to Show Changes Made" following the signature page of this amendment, with additions shown as underlined and deletions [**in brackets**]. In view of the foregoing amendment and the following remarks, Applicant respectfully requests reconsideration and allowance of this application.

#### Claim Rejections-35 U.S.C. §112

The Examiner rejected Claim 5 under 35 U.S.C. §112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains to make or use the invention. By this amendment, Applicant has canceled Claim 5 without prejudice and reserves the right to pursue this claim in the future.

#### Claim Rejections-35 U.S.C. §102(e)

The Examiner rejected Claim 14 under 35 U.S.C. §102(e) as being anticipated by Taguwa (U.S. Patent No. 6,404,058). After carefully reviewing the Taguwa reference, Applicant notes that nowhere in Taguwa does it disclose a contact structure in which a first portion of the titanium layer reacts with silicon in the substrate to form titanium silicide and a *second portion of the titanium layer remains unreacted*. Furthermore, Taguwa does not disclose forming a titanium silicide adhesion layer that is adapted to adhere the unreacted portion of the titanium layer to the titanium nitride contact fill as disclosed in Claim 14. Since Taguwa does not disclose each and every limitation of Claim 14 of the present application, Applicant respectfully submits that Claim 14 is not anticipated by Taguwa.

#### Claim Rejections-35 U.S.C. §103(a)

The Examiner rejected Claims 1-7, 9-14, 16-20 under 35 U.S.C. §103(a) as being unpatentable over Taguwa in view of Thakur et al. (U.S. Patent No. 6,262,485). However, Applicant respectfully submits that Taguwa does not address adhesion problems associated with a contact structure in which the metal silicide layer is formed using a self-aligned silicide process. The self-aligned silicide process poses certain unique problems in that the remaining unreacted metal such as titanium does not adhere well to the titanium nitride contact fill. As such, certain embodiments of the present invention are directed toward improving the adhesion

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between the contact fill and the unreacted titanium on the insulating layer that remains after a self-aligned silicide process.

Taguwa does not address the adhesion between the unreacted titanium formed on the insulating layer after the self-aligned silicide process. In fact, Taguwa does not even disclose a metal silicide layer formed as a result of a self-aligned silicide process. Instead of reacting the titanium with the silicon in the substrate, Taguwa discloses depositing one or more layers of titanium silicide directly onto the substrate to form the metal silicide layer. Thus, there would have been no motivation to combine Taguwa with Thakur to form a contact structure that utilizes a metal silicide adhesion layer to adhere unreacted titanium resulting from a self-aligned silicide process when Taguwa appears to teach forming the metal silicide layer by using a completely different method. Accordingly, Applicant respectfully requests that the rejection of the claims of Taguwa in view of Thakur be withdrawn.

#### CONCLUSION

In view of the foregoing, Applicant respectfully submits that all pending claims of the present application are in condition for allowance, and such action is earnestly solicited. Should there be any impediment to the prompt allowance of this application that could be resolved through a telephone conference, the Examiner is respectfully requested to call the undersigned at the number shown below. Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 2/5/2003

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**Version with Markings to Show Changes Made**

**IN THE CLAIMS:**

Please cancel Claim 5 without prejudice.

Please amend the claims as follows:

*Substrate & metal*

*↳ when anneal'd (heat treat'd),  
→ form silicide*

①

(Amended) An integrated circuit comprising:

a silicon substrate;

an insulating layer formed [over] on the silicon substrate wherein the insulating layer has an opening that extends from an upper surface of the insulating layer to an upper surface of the substrate so as to expose the upper surface of the substrate;

a metal layer formed in the opening wherein a first portion of the metal layer is formed on the exposed upper surface of the substrate and reacts with silicon in the substrate to form metal silicide, wherein a second portion of the metal layer does not contact the substrate and remains unreacted; and

[a metal nitride layer formed over the first and second portions of the metal layer in a manner such that a metal silicide adhesion layer is interposed between the metal nitride and the second portion of the metal layer so as to enhance adhesion between the metal nitride and the second portion of the metal layer;]

a metal silicide adhesion layer formed on an upper surface of the second portion of the metal layer, wherein the metal silicide adhesion layer adheres the second portion of the metal layer to a metal nitride layer that is subsequently formed on the first and second portions of the metal layer.

(\*)

(\*)

*2nd portion*

*applied*

*1st porx  
ind porx  
opposite*

↑

⑭

(Amended) A high aspect ratio contact structure formed over a junction region in a silicon substrate, comprising:

an insulating layer, wherein the insulating layer defines a contact opening, wherein the contact opening is formed over the junction regions of the substrate and exposes a portion of the substrate;

a titanium layer formed in and adjacent the contact opening, wherein a first portion of the titanium layer is formed on the insulating layer and a second portion of the titanium layer is formed on the exposed portion of the substrate, wherein at least a portion of the second portion of the titanium layer contacts the exposed substrate and reacts with the silicon in

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the substrate to form titanium silicide, wherein the first portion of the titanium layer does not contact the substrate;

a titanium silicide adhesion layer formed on an upper surface of the first and second portions of the titanium layer;

a titanium nitride contact fill formed in and adjacent the opening, wherein the titanium nitride is formed on an upper surface of the titanium silicide adhesion layer, wherein the titanium **[silicide adhesion layer adheres the titanium nitride contact fill to the portion of the titanium layer]** nitride contact fill is adhered to the first portion of the titanium layer by the titanium silicide adhesion layer.

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